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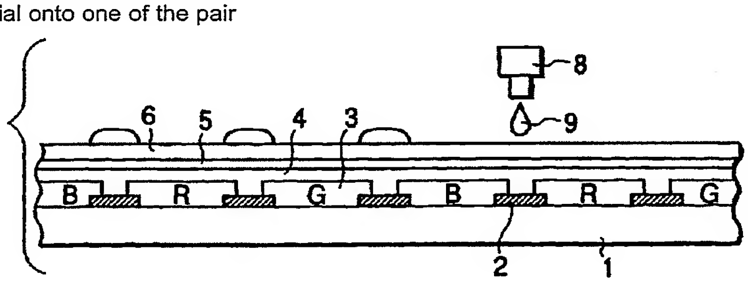
(54) Liquid crystal elemental device, production process thereof and spacer-bearing substrate

(57) Disclosed herein is a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

FIG. 1F



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the pair of substrates by an ink-jet system to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

[0012] According to the present invention, there is also provided a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material a plurality of times to be piled up onto one of the pair of substrates to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

[0013] According to the present invention, there is further provided a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material onto one of the pair of substrates to form the spacer, flattening the top of the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

[0014] According to the present invention, there is still further provided a process for producing a spacer-bearing substrate, which comprises the steps of forming a colored layer on a substrate, and applying a spacer-forming material by an ink-jet system to form a spacer.

[0015] According to the present invention, there is yet still further provided a process for producing a spacer-bearing substrate, which comprises the step of applying a spacer-forming material a plurality of times to be piled up onto a substrate to form a spacer.

[0016] According to the present invention, there is yet still further provided a process for producing a spacer-bearing substrate, which comprises the steps of forming a spacer composed of a spacer-forming material on a substrate, and flattening the top of the spacer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Figs. 1A, 1B, 1C, 1D, 1E, 1F and 1G are flow charts illustrating a production process of a liquid crystal elemental device according to an embodiment of the present invention.

Fig. 2 illustrates how to form a spacer by ejecting a curable, spacer-forming material plural times.

Fig. 3 illustrates an exemplary target shape of a spacer.

Fig. 4 illustrates the construction of an abrading device for abrading a spacer.

Fig. 5 illustrates another exemplary target shape of a spacer.

Fig. 6 is a schematic cross-sectional view illustrating a spacer-bearing substrate according to an embodiment of the present invention.

Fig. 7 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to an embodiment of the present invention.

Fig. 8 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to another embodiment of the present invention.

Figs. 9A, 9B, 9C, 9D, 9E, 9F and 9G are flow charts illustrating a production process of a liquid crystal elemental device according to another embodiment of the present invention.

Fig. 10 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to a further embodiment of the present invention.

Figs. 11A, 11B, 11C, 11D, 11E and 11F are flow charts illustrating a production process of a liquid crystal elemental device according to a further embodiment of the present invention.

Fig. 12 is a schematic cross-sectional view illustrating a spacer-bearing substrate according to another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Figs. 1A to 1G schematically illustrate steps up to the formation of a spacer-bearing substrate in a production process of a liquid crystal elemental device according to an embodiment of the present invention. This embodiment is the case where one substrate is constituted by a color filter with a colored layer and a protective layer provided on a transparent substrate, and a spacer is formed on this substrate. In Figs. 1A to 1G, reference numeral 1 indicates a transparent substrate, 2 a black matrix, 3 a colored layer, 4 a protective layer, 5 a transparent electrode, 6 an orientation film, 8 an ink-jet head, 9 a curable, spacer-forming material, and 10 a spacer. Incidentally, Figs. 1A to 1G are schematic

by weight.

[0029] Examples of the monomer which is a component of the polymer or copolymer contained in the curable, spacer-forming material 9 include N,N-dimethylolacrylamide, N,N-dimethoxymethylacrylamide, N,N-diethoxy-methylacrylamide, N,N-dimethylolmethacrylamide, N,N-dimethoxymethylmethacrylamide and N,N-diethoxymethylmethacrylamide. However, the monomers are not limited thereto. These monomers are used in the form of homopolymers or copolymers with other vinyl monomers. Examples of other vinyl monomers include acrylic acid, methacrylic acid, acrylic esters such as methyl acrylate and ethyl acrylate, methacrylic esters such as methyl methacrylate and ethyl methacrylate, hydroxyl group-containing vinyl monomers such as hydroxymethyl methacrylate, hydroxyethyl methacrylate, hydroxymethyl acrylate and hydroxyethyl acrylate, and besides styrene, α-methylstyrene, acrylamide, methacrylamide, acrylonitrile, allyamine, vinylamine, vinyl acetate and vinyl propionate.

[0030] The copolymerizing proportion, in terms of % by weight, of the above monomer to another vinyl monomer is preferably from 100 %:0 % to 5 %:95 %, particularly desirably from 90 %:10 % to 10 %:90 %.

[0031] When the curable, spacer-forming material is cured by light, various kinds of photosetting resins and photopolymerization initiators may be added thereto. In addition, various kinds of commercially-available resins and additives may be added as other components so far as they do not cause problems of crusting and the like in the curable, spacer-forming material. Specifically, acrylic resins, epoxy resins and the like are preferably used.

[0032] The respective components described above are mixed and dissolved in water and/or a publicly known solvent for the preparation of the curable, spacer-forming material. In this process, those known *per se* in the art may be used. Desirably, an additive solvent or an additive such as a surfactant is added according to the material (orientation film 6 in this embodiment) of the surface of the substrate, on which the spacer 10 is formed, to control the diameter of a dot formed by the curable, spacer-forming material 9 ejected, whereby the diameter of the spacer 10 can be controlled.

[0033] For the ink-jet system used in the present invention, a bubble-jet type making use of an electrothermal converter as an energy-generating element or a piezo-jet type making use of a piezoelectric element may be used. The shot-in quantity of the curable, spacer-forming material 9 may be arbitrarily preset. Although the shot-in position of the curable, spacer-forming material 9 may also be arbitrarily preset, it is preferably shot in a position overlapping with the black matrix.

[0034] A cell gap in a liquid crystal elemental device is generally 2 to 10 μm. In the present invention also, a spacer having a height within this range is preferably formed.

[0035] The spacer may be formed only at positions necessary to hold a cell gap upon fabrication of a liquid crystal elemental device with a plurality of spacers dispersed in the form of a dot or line in the substrate. Each spacer is preferably formed in a substantially cylindrical shape.

[0036] In Step (f), the curable, spacer-forming material 9 may be ejected once to form the spacer 10. However, the curable, spacer-forming material 9 may be ejected plural times at the same position on the substrate by the ink-jet head 8 to overlap each other as illustrated in Fig. 2, thereby forming the spacer 10. The reason for it is that when the curable, spacer-forming material 9 is ejected only once, the curable, spacer-forming material 9 may spread on the orientation film 6 to fail to achieve the height required as a spacer in some cases. Incidentally, when the curable, spacer-forming material 9 is ejected plural times at the same position as described above, the amount of the curable, spacer-forming material ejected later is made less, or after the curable, spacer-forming material 9 ejected earlier is cured to some extent, the curable, spacer-forming material 9 is further ejected thereon, whereby the height necessary for the spacer is achieved with greater ease.

[0037] Fig. 3 is a sectional side elevation illustrating an exemplary target shape of a spacer. It is preferred from the viewpoint of achieving the height necessary for the spacer that the amount of the curable, spacer-forming material ejected later be made less as illustrated in Fig. 2 to form the spacer into such a trapezoid as illustrated in Fig. 3.

[0038] Incidentally, the embodiment illustrated in Fig. 2 shows a case where the curable, spacer-forming material 9 is ejected 3 times at the same position on the substrate to form the spacer 10. However, the present invention is not limited to the threefold ejection, but the spacer may be formed by twofold ejection, or fourfold or more ejection.

Step (g):

[0039] The curable, spacer-forming material 9 is cured by light irradiation, heat treatment or both light irradiation and heat treatment to form the spacer 10, thereby obtaining a spacer-bearing substrate according to the present invention. The light irradiation and heat treatment are conducted in accordance with the respective methods known *per se* in the art.

[0040] When the spacer requires specially strict evenness, the surface of the spacer 10 may be abraded and flattened according to the following Step (h). In this case, shavings remained after the abrasion are preferably cleaned off in the following Step (i).

ejection orifice, a liquid path and an electrothermal converter as disclosed in the above-described respective U.S. Patents (linear liquid path or right-angle liquid path), the construction disclosed in U.S. Patent Nos. 4,558,333 and 4,459,600 that a heat acting surface is arranged in a curved region is also embraced in the present invention. In addition, the construction based on Japanese Patent Application Laid-Open No. 59-123670 disclosing the construction that a slot common to a plurality of electrothermal converters is used as an ejection part of the electrothermal converters, or Japanese Patent Application Laid-Open No. 59-138461 disclosing the construction that an opening absorbing the pressure wave of thermal energy is arranged in opposed relation to an ejection part may also be allowable.

[0054] Further, a full-line type recording head having a length corresponding to the width of the greatest recording medium on which recording can be conducted by a recording apparatus may be either the construction that the length is fulfilled by such a combination of plural recording heads as disclosed in the above-described U.S. Patents or the construction as one recording head formed integrally.

[0055] Thereafter, the above-described spacer-bearing substrate and an opposed substrate fabricated separately are laminated with a sealant to fabricate a cell, and a liquid crystal is enclosed in the cell, thereby obtaining the liquid crystal elemental device according to the present invention.

[0056] Examples of the liquid crystal elemental device according to the present invention are illustrated in Figs. 7 and 8. Fig. 7 is a schematic cross-sectional view illustrating an exemplary liquid crystal elemental device fabricated by using the spacer-bearing substrate according to the present invention illustrated in Fig. 1G. Fig. 8 is a schematic cross-sectional view illustrating an exemplary liquid crystal elemental device fabricated by using the spacer-bearing substrate according to the present invention illustrated in Fig. 6. In Figs. 7 and 8, reference numeral 11 indicates an opposed substrate, 12 pixel electrodes, 13 an orientation film, and 14 a liquid crystal. These liquid crystal elemental devices are examples of an active matrix type (so-called TFT type) liquid crystal elemental device in which a TFT (thin film transistor) is arranged for every pixel.

[0057] Liquid crystal elemental devices for colored display are generally formed by uniting the substrate 1 on the side of the color filter and the opposed substrate 11 and enclosing the liquid crystal 14 in a space between both substrates. On the inside of the opposed substrate 11, TFTs (not illustrated) and the transparent pixel electrodes 12 are formed in the form of a matrix. On the inside of the transparent substrate 1, the colored layer 3 of the color filter is provided in such a manner that colored portions of R, G and B are arranged at positions opposite to the pixel electrodes 12. The transparent electroconductive film (common electrode) 6 is formed onto the whole surface of the colored layer. The black matrix 2 is generally formed on the side of the color filter, but formed on the side of the opposed substrate 11 in a liquid crystal elemental device of the BM on array type. The orientation films 6 and 13 are further formed on the respective insides of both substrates. Liquid crystal molecules can be aligned or oriented in a fixed direction by subjecting these films to a rubbing treatment. These substrates are arranged in opposed relation to each other through the spacer 10 and laminated with a sealant (not illustrated). The liquid crystal 14 is filled in a space between both substrates. For the liquid crystal, any of a commonly used TN type liquid crystal, ferroelectric liquid crystal, etc. may be used.

[0058] In the case where the liquid crystal elemental device is of a transmission type, polarizing plates are arranged on the outsides of both substrates, and a back light generally composed of a combination of a fluorescent lamp and a scattering plate is used, or in the case where the liquid crystal elemental device is of a reflection type, a polarizing plate is arranged on the outside of the transparent substrate 1. In each case, the liquid crystal 14 functions as an optical shutter for changing the transmittance of light, thereby conducting display.

[0059] Although the TFT type liquid crystal elemental devices have been described in the above embodiments. However, the present invention is also preferably applied to liquid crystal elemental devices of other drive types such as the simple matrix type. The liquid crystal elemental devices according to the present invention are suitably used in both direct viewing type and projection type.

[0060] A spacer-forming material according to another embodiment will hereinafter be described.

[0061] As the spacer-forming material, may be used a bead-containing spacer-forming material in which beads are dispersed in an adhesive.

[0062] The bead-containing spacer-forming material according to the present invention is formed into the spacer 10 by applying it onto the color filter and then curing the adhesive to fix the beads to the color filter.

[0063] For the bead-containing spacer-forming material according to the present invention, a ratio of the specific gravity of the beads to the specific gravity of the adhesive is 0.9 to 1.1, desirably 0.95 to 1.05 from the viewpoint of preventing the precipitation or flotation of the beads in the spacer-forming material.

[0064] For the beads contained in the bead-containing spacer-forming material according to the present invention, those having a particle diameter of 0.8 to 10 μm are preferably used from the viewpoint of holding a cell gap in the resulting liquid crystal elemental device, and they are contained in a proportion of preferably 0.1 to 50 % by weight, more preferably 1 to 30 % by weight in the spacer-forming material. Further, the viscosity of the adhesive is adjusted to preferably 2 to 100 cp, more preferably 3 to 50 cp at 25°C from the viewpoint of successfully ejecting the spacer-forming material.

Step (b):

[0079] Patterning exposure is conducted through a photomask 54 to form the coloring portions 56 having high ink absorbency and non-coloring portions 55 the ink absorbency of which is lower (or lost) than that of the coloring portions 56. In this embodiment, the photosensitivity of the ink-receiving layer 53 is negative, and in this case, a photomask having such an opening pattern that the width of each of the non-coloring portions 55 becomes narrower than the width of the black matrix 2 is preferably used from the viewpoint of forming colored portions 59 wider than the aperture of the black matrix 2 to prevent color skip at aperture portions of the black matrix 2.

[0080] In the case where the photosensitivity of the ink-receiving layer 53 is positive, the black matrix 2 is used as a photomask to conduct exposure from the back side of the transparent substrate 1, whereby the patterning exposure can be conducted without using any photomask.

Step (c):

[0081] Color inks 58 of R (red), G (green) and B (blue) colors are applied to the coloring portions 56 of the ink-receiving layer according to the prescribed coloring pattern by means of an ink-jet head 57. In this embodiment, the non-coloring portions 55 low (or lost) in ink absorbency are interposed between adjacent coloring portions 56, so that the respective inks overflowed from the coloring portions 56 are repelled by the non-coloring portions 55, thereby preventing color mixing between the adjacent coloring portions 56.

[0082] For the color inks used in the present invention, both dye inks and pigment inks may be used, and any inks may be used so far as they can be ejected by an ink-jet system.

[0083] For the ink-jet system used in the present invention, a bubble-jet type using an electrothermal converter as an energy-generating element, a piezo-jet type making use of a piezoelectric element, or the like may be used. A coloring area and a coloring pattern may be arbitrarily preset.

Step (d):

[0084] After the color inks 58 are absorbed in the respective coloring portions 56 and sufficiently diffused, the ink-receiving layer is subjected to a drying treatment as needed, and the whole surface of the ink-receiving layer is subjected to a necessary treatment such as light irradiation and/or heat treatment to cure the whole ink-receiving layer to form a colored layer composed of the non-coloring portions 55 and the colored portions 59.

Step (e):

[0085] After a protective layer 4 is formed as needed, a transparent electroconductive film 5 which will become an electrode for driving a liquid crystal is formed.

[0086] For the transparent electroconductive film 5, ITO (indium-tin-oxide) film is generally used. Such a film can be formed by sputtering or the like.

Step (f):

[0087] A spacer-forming material 9 is partially applied in, preferably, a region overlapping with the black matrix 2 by an ink-jet head 8.

Step (g):

[0088] The spacer-forming material 9 is subjected to a necessary treatment such as light irradiation, heat treatment or both light irradiation and heat treatment to cure the spacer-forming material 9, thereby forming the spacer 10 to obtain a spacer-bearing color filter according to the present invention. The light irradiation and heat treatment are conducted in accordance with the respective methods known *per se* in the art.

[0089] Figs 11A to 11F illustrate steps of a production process of a spacer-bearing color filter according to another embodiment of the present invention. In Figs. 11A to 11F, like reference numerals are given to the same members as in Figs. 9A to 9G, and their descriptions are omitted. In Figs. 11A to 11F, reference numeral 32 indicates a black matrix, 57 an ink-jet head, 38 curable color inks, and 39 colored portions. Incidentally, Figs. 11A to 11F correspond to the following Steps (a) to (f), respectively.

EXAMPLE 1:

[0103] A metal chromium film having a thickness of 0.1 μm was formed on a glass substrate by sputtering and etched by using a photoresist, thereby obtaining a lattice black matrix. Thereafter, a colored layer composed of colored patterns of R, G and B was formed by using a publicly known process for forming a color filter by an ink-jet system. A protective layer composed of an acrylic resin was formed thereon by means of a spin coater to conduct smoothing. An ITO film as a transparent electrode was further formed thereon by sputtering, and an orientation film composed of polyimide was further formed thereon. A curable, spacer-forming material having the following composition was ejected to this substrate onto the black matrix by an ink-jet head as illustrated in Fig. 1F.

[Composition of curable, spacer-forming material]

[0104]

Copolymer	10 % by weight
Water	80 % by weight
Ethylene glycol	10 % by weight.

[0105] The copolymer used in the above composition was a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (copolymerization ratio = 40:60 by weight).

[0106] The above-prepared substrate was heated at 100°C for 15 minutes, and then at 200°C for 30 minutes to cure the curable, spacer-forming material, thereby forming a spacer.

[0107] The substrate on which the spacer had been formed and a substrate on which opposed electrodes had been formed were laminated with a sealant to fabricate a cell. A liquid crystal was filled into the cell to obtain a liquid crystal elemental device according to the present invention. The liquid crystal elemental device thus obtained was less in color irregularity and excellent in contrast compared with a conventional liquid crystal elemental device in which spacers having a diameter of 6 μm are dispersed.

EXAMPLE 2:

[0108] A metal chromium film having a thickness of 0.1 μm was formed on a glass substrate by sputtering and etched by using a photoresist, thereby obtaining a lattice black matrix. Thereafter, a colored layer composed of colored patterns of R, G and B was formed by using a publicly known process for forming a color filter by an ink-jet system. A protective layer composed of an acrylic resin was formed thereon by means of a spin coater to conduct smoothing. An ITO film as a transparent electrode was further formed thereon by sputtering. A curable, spacer-forming material having the following composition was ejected to this substrate onto the black matrix by an ink-jet head in the same manner as in EXAMPLE 1. Incidentally, an orientation film composed of polyimide was formed after the formation of the spacer.

[Composition of curable, spacer-forming material]

[0109]

Copolymer	10 % by weight
Water	80 % by weight
Ethylene glycol	10 % by weight.

[0110] The copolymer used in the above composition was a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (copolymerization ratio = 40:60 by weight).

[0111] In this example, the curable, spacer-forming material was ejected 3 times to form the spacer. In this case, the spacer-forming material was ejected on the substrate in an amount of 20 ng for the first ejection, 15 ng for the sec-

[Composition of acrylic terpolymer]

[0122]

methyl methacrylate	50 parts by weight
hydroxyethyl methacrylate	30 parts by weight
N-methylolacrylamide	20 parts by weight.

[0123] The ink-receiving layer was subjected to patterning exposure in the form of stripe at part of the ink-receiving layer on the black matrix through a photomask having stripe openings each having a width narrower than that of the black matrix, and then subjected to a heat treatment for 1 minute on a hot plate heated to 120°C. Dye inks of R (red), G (green) and B (blue) colors were applied to unexposed portions of the ink-receiving layer by means of an ink-jet recording apparatus, thereby coloring the ink-receiving layer in the form of stripe with continuous dots. The inks were then dried at 90°C for 5 minutes. The substrates thus colored was subsequently subjected to a heat treatment at 200°C for 60 minutes to cure the whole ink-receiving layer, thereby obtaining a colored layer.

[0124] A two-pack type thermosetting resin composition ("SS6699G", trade name, product of JSR Co., Ltd.) was spin-coated on the colored layer so as to give a film thickness of 1 μm and prebaked at 90°C for 30 minutes. The thus-formed film was heat-treated at 250°C for 60 minutes to form a protective layer. An ITO film was then formed by sputtering so at to give a thickness of 1,500 Å, thereby obtaining a color filter.

[0125] Beads (divinylbenzene-crosslinked polystyrene; specific gravity: 1.02) having a particle diameter of 5.5 μm were dispersed in an adhesive (specific gravity: 0.98) composed of 10 % by weight of a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (weight ratio = 40:60), 80 % by weight of water and 10 % by weight of ethylene glycol in such a manner that the content of the beads in a spacer-forming material was 10 % by weight, thereby preparing a bead-containing spacer-forming material. The viscosity of this spacer-forming material was 19 cp at 25°C. The bead-containing spacer-forming material was applied onto the ITO film by an ink-jet head in such a manner that the beads were partially arranged in a region overlapping with the black matrix. The beads were uniformly dispersed in the spacer-forming material in this application step and have been applied to desired positions on the black matrix. The thus-treated substrate was subjected to an additional heat treatment at 150°C for 20 minutes to cure the adhesive, thereby fixing the beads to the ITO film to obtain a spacer-bearing color filter.

[0126] The spacer-bearing color filter thus obtained was used to fabricate a liquid crystal elemental device for color display. As a result, a good color image was displayed.

EXAMPLE 5:

[0127] A resin composition comprising 97 parts by weight of an acrylic terpolymer having the following composition, and 3 parts by weight of triphenylsulfonium hexafluoroantimonate dissolved in ethyl cellosolve was applied onto a glass substrate, on which a lattice black matrix (aperture size: 100 μm × 300 μm) having a width of 20 μm and a length of 40 μm had been formed with chromium, by spin coating so as to give a film thickness of 2 μm, and prebaked at 90°C for 20 minutes, thereby forming an ink-receiving layer.

[Composition of acrylic terpolymer]

[0128]

methyl methacrylate	50 parts by weight
hydroxyethyl methacrylate	30 parts by weight
N-methylolacrylamide	20 parts by weight.

[0129] The ink-receiving layer was subjected to patterning exposure in the form of stripe at part of the ink-receiving layer on the black matrix through a photomask having stripe openings each having a width narrower than that of the

to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

10. The process according to Claim 9, wherein when the spacer-forming material is applied a plurality of times, the amount of the spacer-forming material applied in and after the second time is smaller than the amount of the spacer-forming material applied in the first time.

11. The process according to Claim 9, wherein when the spacer-forming material is applied a plurality of times, the spacer-forming material applied earlier is cured, and then the next spacer-forming material is applied thereon.

12. The process according to Claim 9, wherein the substrate on which the spacer is formed has a colored layer.

13. The process according to Claim 9, wherein the spacer-forming material is applied by an ink-jet system.

14. A process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material onto one of the pair of substrates to form the spacer, flattening the top of the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

15. The process according to Claim 14, wherein the substrate on which the spacer is formed has a colored layer.

16. The process according to Claim 14, wherein the spacer-forming material is applied by an ink-jet system.

17. A process for producing a spacer-bearing substrate, which comprises the steps of forming a colored layer on a substrate, and applying a spacer-forming material by an ink-jet system to form a spacer.

18. A process for producing a spacer-bearing substrate, which comprises the steps of applying a spacer-forming material a plurality of times to be piled up onto a substrate to form a spacer.

19. The process according to Claim 18, wherein the substrate on which the spacer is formed has a colored layer.

20. The process according to Claim 18, wherein the spacer-forming material is applied by an ink-jet system.

21. A process for producing a spacer-bearing substrate, which comprises the steps of forming a spacer composed of a spacer-forming material on a substrate, and flattening the top of the spacer.

22. The process according to Claim 21, wherein the substrate on which the spacer is formed has a colored layer.

23. The process according to Claim 21, wherein the spacer-forming material is applied by an ink-jet system.

FIG. 2

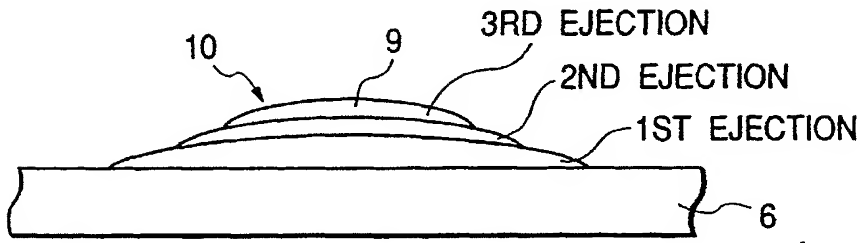
10
9
3RD EJECTION
2ND EJECTION
1ST EJECTION
6

FIG. 3

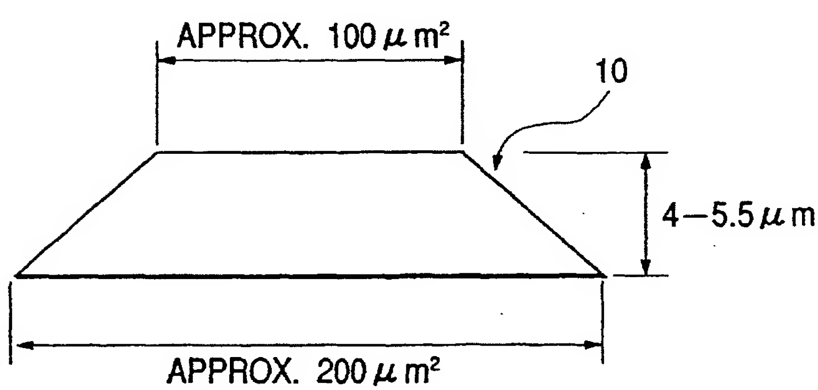
APPROX. 100 μm²
10
4−5.5 μm
APPROX. 200 μm²

FIG. 6

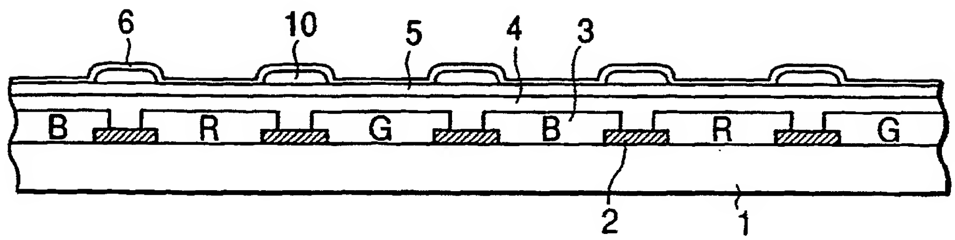

FIG. 7

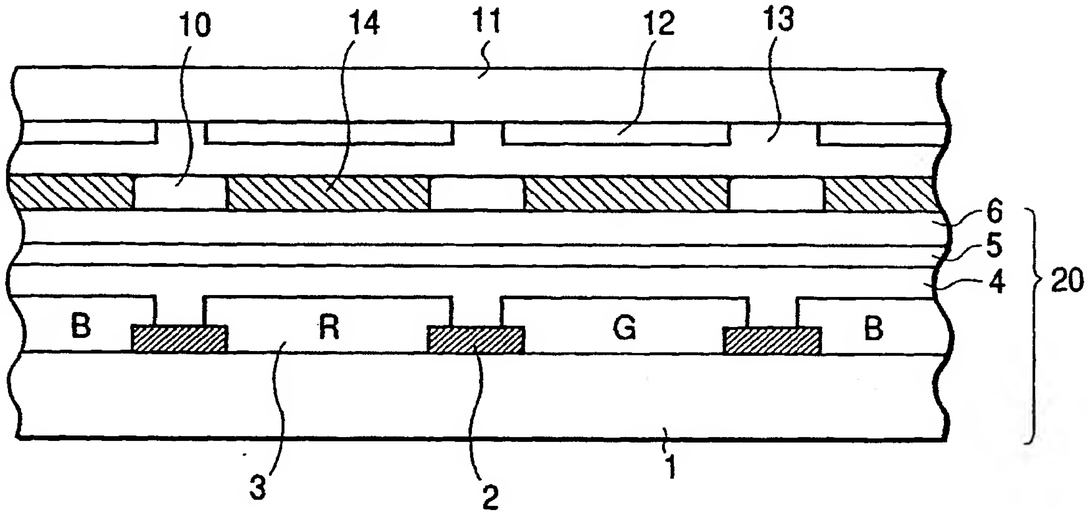

FIG. 8

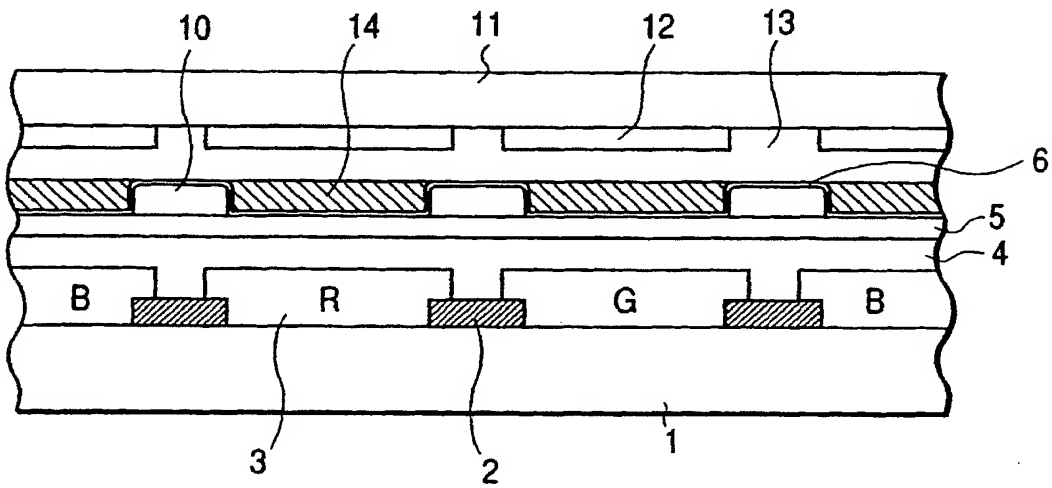

FIG. 9F

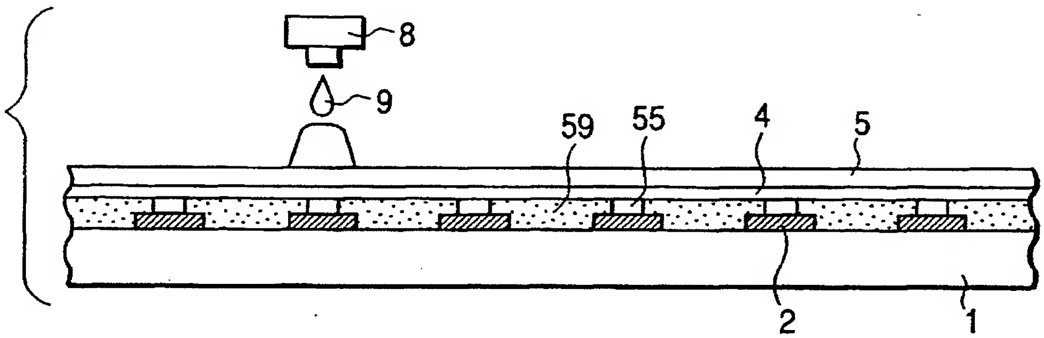

FIG. 9G

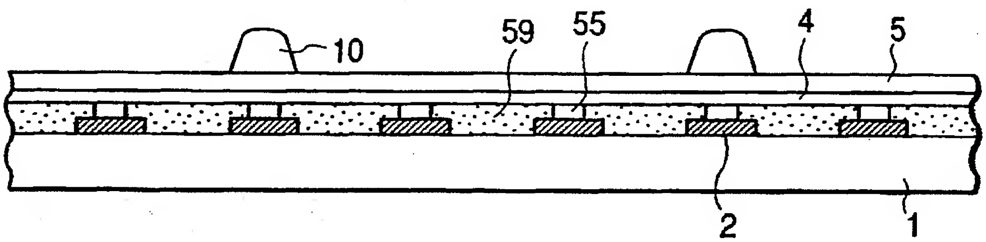

FIG. 10

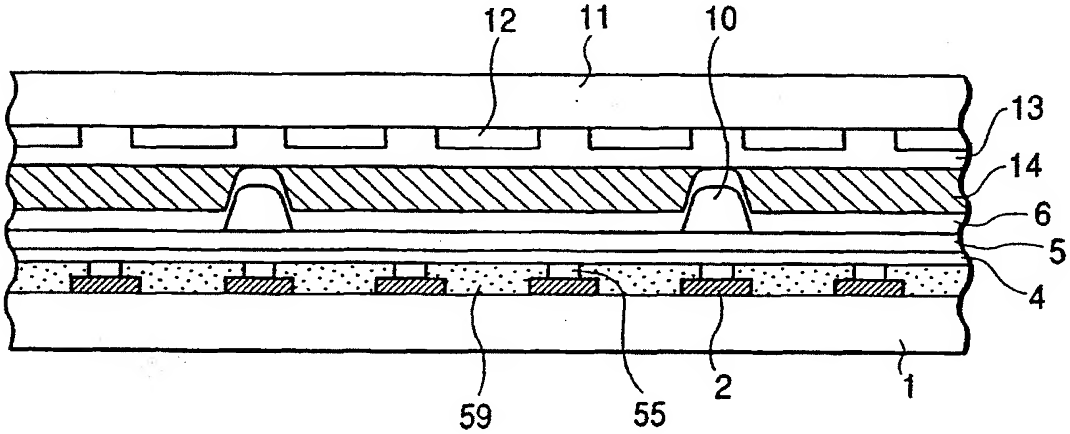

FIG. 12